What Leeuwenhoek Saw

hhmi | BioInteractive

Card Activity
Student Handout

INTRODUCTION

Back in the 1600s, Antonie van Leeuwenhoek, a fabric merchant in Holland, developed simple, homemade microscopes and began observing with them. Imagine his surprise when he looked at a drop of lake water and saw hundreds of tiny microorganisms swimming inside!

The images of the cells and microorganisms that you see in your textbooks and online are magnified; otherwise, you wouldn't be able to see most of them. In this activity, you will use scale bars to calculate the actual sizes of several cells and microorganisms and then compare relative sizes. The cells and microorganisms used in this activity are some of the ones that van Leeuwenhoek first observed with his microscopes.

MATERIALS

- 1 set of Cells and Microorganisms cards distributed by teacher
- Metric rulers
- Calculators
- Craft supplies: paper, card stock or construction paper, tape, scissors
- Optional supplies: string, yarn, colored pencils or markers

PROCEDURE

Part 1: Cells and Microorganisms cards

Examine the cards distributed by your teacher and follow the given instructions.
Record observations and notes here:

Part 2: Metric Units and Conversions

Use the supplemental sheet to review metric units and conversions.

Part 3: Watch the Video Animated Life: Seeing the Invisible

After watching the video, imagine that you can ask van Leeuwenhoek about the organisms he saw or about the ones you viewed on the cards you examined in Part 1. Make a list of questions you might ask him:

Part 4: Calculating Magnification and Scale

One of the microorganisms shown in the short film is *Daphnia*, also known as a "water flea." *Daphnia* is the genus name for many species of small, freshwater crustaceans. In spite of its tiny size, *Daphnia* are multicellular, eukaryotic animals. *Daphnia ambigua* is one of the smallest known *Daphnia* species.

The image of the *Daphnia ambigua* below is a **scale model,** which means that it shows all the relevant characteristics of the actual microorganism drawn to scale.

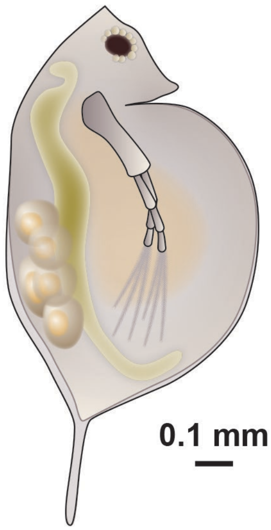

Figure 1. A drawing of *Daphnia ambigua*. Note the scale bar that indicates the length that corresponds to 0.1 mm.

You can calculate the actual size of the *Daphnia ambigua* shown in the image by measuring the length and width of the microorganism in the drawing and then measuring the length of the scale bar below it. In this case, the scale bar is 5 mm long, but that measurement represents 0.1 mm.

Because the measured (or scaled) dimension (5 mm) is larger than the actual dimension that is given for the scale bar (0.1 mm), you know this image (and the scale bar) has been magnified. But by how much?

To calculate the magnification factor, use the following formula:

scaled dimension/actual dimension = magnification

5 mm/0.1 mm = 50

Once you know the magnification factor, you can calculate the actual size of the *Daphnia*.

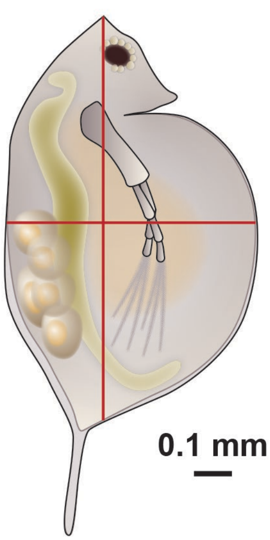

Figure 2. A drawing of *Daphnia ambigua* with guidelines for accurate measurement. The red lines indicate the maximum width and length of the organism. Note the scale bar that indicates the length that corresponds to 0.1 mm.

1. Use your ruler to measure the dimensions of the *Daphnia* in Figure 2.
   Daphnia's width at its widest point: ________________ mm
   Daphnia's body length (without the tail): ________________ mm

2. To determine the actual dimensions of the *Daphnia*, you will divide the measurements above by the magnification factor. Also convert the mm units to µm.
   Daphnia's actual width: scaled dimension/50 = _____ mm = _____ µm
   Daphnia's actual length: scaled dimension/50 = _____ mm = _____ µm

3. How big would the *Daphnia* image be if it were magnified 1000 times? Note: Since there are 1,000 µm in a mm, the measurements when provided in µm are easily converted to mm.
   Calculate the size in mm, showing your work:
   Daphnia's width at its widest point in µm, magnified 1,000×: ________________ mm
   Daphnia's length in µm, magnified 1,000×: ________________ mm

4. Create a model of *Daphnia* magnified 1,000× with paper, cutting the paper to approximate the shape using your maximum length and width calculations.

5. How does the size of your paper model compare to those cut out by your classmates?

6. The period at the end of this sentence is a circle measuring 0.5 mm in diameter, which is 500 µm (0.5 mm × 1,000 µm/1 mm). If the period is magnified 1,000×, calculate the diameter of the period in mm.
   Diameter of period, magnified 1,000×: ________________ mm

7. Cut out a paper model of the period multiplied 1,000×. Is it bigger or smaller than the *Daphnia*?

8. The magnification factor for a scale bar that is 2 mm long and represents a length of 8 µm would be calculated as follows:
   Scaled dimension/actual dimension = magnification factor
   2000 µm/8 µm = 250

Determine how large you would make a model microorganism magnified 1000× if its image at the maximum width is 40 mm and at its maximum length is 80 mm. Complete the table below to determine the answer.

	Measurement in mm	**Magnification Factor**	**Actual measurement (in µm)**	**Measurement when magnified 1,000× (in mm)**
Length	**80 mm**	**250**		
Width	**40 mm**	**250**		

Part 5: Build Your Own Scale Model

Use everything you just learned about magnification and scale to calculate the actual size of a cell or microorganism, and then to draw a scale model of that cell or microorganism magnified 1,000×.

- Select a specimen card from the deck of cards.
- Use the information on the card to calculate the measurements for your selected cell or microorganism in the table below. For cards that show more than one organism, select and measure one.
- Construct a **scale model** of your organism magnified 1,000×.
- Follow your teacher's instructions to display your model(s).
- After completing the models, answer the analysis questions.

Name of cell or microorganism: ____

	Measurement from card (in mm or cm)	Magnification Factor	Actual size (in µm)	Size when magnified 1,000× (in mm or cm)
Length				
Width				

Analysis Questions:

1. Which of the cells or microorganisms that you and your classmates modeled are larger than a 0.5-mm period?

   Smaller than a period?

2. Van Leeuwenhoek's microscope was only capable of 200× magnification. Microscopes today, such as scanning electron (SEM) and transmission electron (TEM) microscopes, are far more powerful and magnify up to 10,000,000×!
   a. What would the diameter of a 500-µm period be when magnified 10,000,000×?
   _________________ m
   b. Why do you think scientists would need such strong magnification?

OPTIONAL: METRIC UNITS AND CONVERSIONS

Some of the length units you might be familiar with are meter (m), centimeter (cm), and millimeter (mm). Because we are working with microorganisms, it is useful to know how to convert between these units and a much smaller unit called the micrometer (µm).

For example, an animal cell is 10 µm in size. That's much easier to write than 0.00001 m, but the two measurements mean the same thing.

To convert among different units, you need to use **conversion factors.** A conversion factor is a ratio between two equivalent numbers. For example, if a paperclip is 0.032 m long, how long is it in centimeters?

Since 1 meter is equal to 100 cm, the conversion factor you will use is **100 cm/1 m**:

0.032 m × conversion factor = size of paperclip in cm

0.032 m × 100 cm/1 m = 3.2 cm/1 = <u>3.2 cm</u>

Alternatively, you can set up a ratio:

100 cm/1 m = *x* cm/0.032 m

x = <u>3.2 cm</u>

What if you wanted to know how long a 0.032-m paperclip is in millimeters (mm)?
There are 1,000 mm in a meter, so you can use the conversion factor **1,000 mm/1 m** and complete the calculation in the following way:

0.032 m × 1,000 mm/1 m = 32 mm/1 = <u>32 mm</u>

Or, set up a ratio:

1 m/1,000 mm = 0.032 m/*x* mm

x = <u>32 mm</u>

Finally, what about in micrometers (µm)? There are 1,000,000 µm in a meter, so the conversion factor is **1,000,000 µm/1 m**. The calculation is:

0.032 m × 1,000,000 µm/1 m = 32,000 µm/1 = <u>32,000 µm</u>

Or, set up a ratio:

1 m/1,000,000 µm = 0.032 m/*x* µm

x = <u>32,000 µm</u>

The following table will help you find the conversion factors needed for the practice problems. Complete the missing numbers:

Meters	Centimeters	Millimeters	Micrometers
1 m =	100 cm =	1,000 mm =	1,000,000 µm
0.01 m =	__ cm =	10 mm =	__ µm
__ m =	0.1 cm =	__ mm =	1,000 µm
__ m =	__ cm =	0.001 mm =	__ µm

Practice Problems

Use the appropriate conversion factors to calculate each of the following and show your work for each:

1. Use a ruler to measure the width of your index finger in centimeters (cm).
   Record the measurement here: __________
   a. How wide is your index finger in meters (m)? __________
   b. In millimeters (mm)? __________
   c. In micrometers (µm)? __________
2. An average human skin cell measures 30 µm in diameter.
   a. What is the diameter in millimeters (mm)? _________
   b. In centimeters (cm)? __________
   c. In meters (m)? __________
3. If you lined up human skin cells side-by-side, how many would fit across the width of your index finger? Explain your reasoning.